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Experimental Investigations on Influence of Carbon Composite Fibres in Concrete

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ABSTRACT: The use of short pitch-based carbon fibres (0.05% of weight of cement, 0.189 vol. % Concrete), together with a dispersant, chemical agents and silica fume, in concrete with fine and coarse aggregates resulted in a flexural strength increase of 85%, and a flexural toughness increase of 205%, a compressive strength increase of 22%, and a material price increase of 39%. The slump was 4 in at a water/cement ratio of 0.50. The air content was 6%, so the freeze-thaw durability was increased, even in the absence of an air entertainer. The aggregate size had little effect on the above properties. The minimum carbon fiber content was 0.1 vol. %. The optimum fiber length was such that the mean fiber length decreased from 12 mm before mixing to 7 mm after mixing, which used a Hobart mixer. The drying shrinkage was decreased by up to 90%. The electrical resistivity was decreased by up to 83%.To investigate the effect of carbon fibres on M20 concrete.

The parameters considered percentage of carbon fibres (0.1,0.5&0.1%) and three aspect ratios (50,75,100).Compressive strength, tensile strength are the two major properties are to be investigated. To investigate influence of carbon fibres on the properties of concrete. To obtain stress-strain characteristics of carbon fibre reinforced concrete. To establish the failure criteria of carbon fibre reinforced concrete under uniaxial and biaxial stress conditions.

KEYWORDS

Carbon fibres, Compressive Strength, Tensile Sterngth

I. INTRODUCTION

Smart concrete is reinforced by carbon fibre as much as 0.2% and 0.5% of volume to increase its sense ability to strain or stress while still as good mechanical properties.

By adding small amount of short carbon fibres into concrete with a conventional concrete mixer, the electrical resistance of concrete increases in response to strain or stress. As the concrete is deformed or stressed, the contact between the fibre and cement matrix is affected, thereby affecting the volume electrical resistivity of the concrete. Strain is detected through measurement of the electrical resistance. So, the smart concrete has the ability to sense tiny structural flaws before they become significant, which could be used in monitoring the internal condition of structures and following an earthquake.

In addition, the presence of the carbon fibres also controls the cracking so that the cracks do not propagate catastrophically, as in the case of conventional concrete.

Smart structures capable of non-destructive health monitoring in real time are of increasing importance due to the need to maintain the functions of critical civil infrastructures systems. Structures in earthquake prone regions are in particular need of in-situ health monitoring.

The sensing function refers to the ability to provide an electrical or optical response to damage such as cracks in real time during dynamic loading. Requirements of the sensor include the following: 1) low cost for both materials and implementation; 2) durability and reliability; 3) measurement repeatability and stability; 4) ability to provide quantitative signals with high sensitivity and resolutions; 5) ability to provide spatial resolution; 6) fast response for real-time monitoring; 7) sensitivity to a wide dynamic range of strain, covering both the elastic and inelastic regimes of deformation; 8) not weakening the structure; 9) not requiring expensive peripheral equipment; and 10) applicability to both old and new structures. The ability to detect and distinguish between inelastic deformation and elastic deformation. This valuable for monitoring damage occurrence during dynamic loading as it provides monitoring of the dynamic loading in its complete range, covering both the elastic and inelastic regimes. Thus, it allows determination of exactly in which part of which loading cycle damage occurs and does not require the load cycling to be periodic in time.

II. SIGNIFICANCE OF STUDY

The Significance of study on Smart materials and systems open up new possibilities, such as clothes that can interact with a mobile phone or structures that can repair themselves. They also allow existing technology to be improved. Using a smart material instead of conventional mechanisms to sense and respond, can simplify devices, reducing weight and the chance of failure.

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III. RESEARCH SIGNIFICANCE

In this technology, concrete itself is the sensor, so there is no need to embed strain gages, optical fibres, or other sensors in the concrete. This sensor satisfies all of the requirements. Moreover, the intrinsically smart concrete exhibits high flexural strength and toughness and low drying shrinkage. The sensing ability and its origin are described systematically in relation to the sensing of elastic deformation, inelastic deformation, and fracture. In contrast to techniques such as acoustic emission, which cannot sense elastic deformation, this new sensor technology allows the sensing of elastic deformation in addition to inelastic deformation and fracture. The signal provided by this new sensor is the change in the electrical resistance, reversible strain is associated with reversible resistance change and irreversible strain is associated with irreversible resistance change, whereas fracture is associated with irreversible and particularly large resistance change. The origin of the signal associated with fracture is crack propagation, which increases resistance due to the high resistivity of the cracks. The origin of the signal associated with irreversible strain is conducting fibre breakage, the origin of the signal associated with reversible strain in conducting **fibre** pullout. The detection of fracture does not require fibres in the concrete, where as the detection of irreversible and reversible strains require the presence of short and electrically conducting fibres in the concrete.

IV. OBJECTIVE

- To investigate the influence of carbon fibres on the properties of mortar in compression and tension.
- To obtain the relationship between load vs change in resistance of mortar in properties of mortar in compression and tension.

V. Experimental Investigation

Experimental investigations have been carried as per the scheme of work. Some of the important properties like Specific Gravity, Fineness Modulus, Dry rodded bulk density and crushing strength to be considered for the selection of materials have been investigated.

A. Properties of Material

Table 1: Properties of cement (IS 12269:1987)

S.No	Properties	Experimental results	Values as per code/standard (IS12269:1987)
1	Fineness(Sieve analysis)	10%	<15%
2	Specific Gravity	3.14	3.15

Table 2: Properties of Fine aggregate (IS 383:1970)

S.No	Properties	Experimental results
1	Specific Gravity	2.6
2	Fineness Modulus	2.65

Table 3: Properties of Coars aggregate (IS 383:1970)

S.No	Properties	Experimental results
1	Specific Gravity	2.6
2	Fineness Modulus	2.65

B. Scheme Of Investigation

Table 3 :

Test	Mortar Specimen size in mm	No of specimens	Other Non destructive properties
Compressive strength	100x100x100	21	Ultra Sonic Pulse Velocity Rebound Hammer Electrical Resistivity
Split tensile strength	100mm diameter and 200mm height	21	Electrical Resistivity
Flexural strength	500x100x100	3	Electrical Resistivity
	Total number of specimens	45	

C. Raw materials

The fibres used were carbon fibres. They were short, isotropic pitch-based, and utilized. The nominal fibre length was 5mm. The fibres in the amount of 0.5 percent by weight of cement were used, unless stated otherwise. The aggregate used was natural sand, the particle- size analysis. Table 3.7 describes the four types of mortar studied. They are: 1) plain mortar; 2) plain mortar with latex; 3) plain mortar with methylcellulose; 4) plain mortar with methylcellulose and silica fume. The tensile specimen contains no sand due to their small cross-sectional area, where as the compressive and flexural specimens contained sand. The latex, methylcellulose, and silica fume were added partly for the purpose of enhancing fibre dispersion, but in each category such additives were used whether fibres were present or not to obtain the effect of the fibre addition alone. In addition, latex and silica fume served to enhance the fibre-matrix bonding

D. Testing Procedure

a. Strength Properties

The specimen dimensions depended on the deformation mode compressive, tensile, and flexural. They are all in accordance with ASTM standards for mortar or concrete.

For compressive testing mortar specimens were prepared by ysing a 100mmx100mmx100mm mold.

Fig 1 : Typical Testing for cube specimen

For tensile testing mortar specimens were prepared by using a 150mm diameter and 200mm length mold. Split tensile was performed using Compressive testing machine(CTM) (See Fig 2).

Fig 2 : Typical testing of cylinder specimen

b. Electrical Resistance Properties

During compressive or tensile loading up to fracture, the strain was measured by the crosshead displacement in compressive testing and in tensile testing, while the fractional change in electrical resistance was measured using the four probe method.

A four point probe is a simple apparatus for measuring the resistivity of semiconductor samples. By passing a current through two outer probes and measuring the voltage through the inner probes allows the measurement of the substrate resistivity.

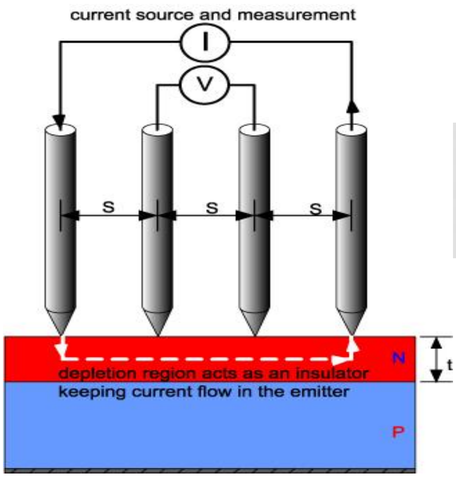

Fig 3 : Schematic diagram of four probe method

The resistance of an object is defined as the ratio of voltage across it to current through it, while the conductance is the inverse:

$$R = V/I \ldots(1)$$

The resistance was measured in ohms. Ohm's law is an empirical law relating the voltage V across an element to the current I through it:

$$V \propto I \ldots(2)$$

The resistance R is defined by

$$R = V/I \ldots(3)$$

Flexural testing was performed by two point bending with a span of 140mm. The specimen size was 500x100x100 mm. Flexural testing was performed using a screw type mechanical testing system. During flexural loading up to fracture, the fractional change in electrical resistance was measured separately at the top surface and the bottom surface. Electrical contacts were made by silver paint applied along four parallel lines on each of the opposite surfaces of the specimen. Resistance measurements were all made at a DC current in the range from 0.1 to 4 A.

Fig 4 : Typical testing of electrical resistance in compression

Fig 4 : Typical testing of electrical resistance in tension

Fig 4 : Typical testing of electrical resistance in flexural

VI. Test Results & Discussions

A. Verification of Mix design

Table 4 : Results of Compressive Strength

Type of Concrete	Specimen	Weight in Kg	Compressive Strength (7 days) N/mm^2
Plain Concrete	1	8.830	18.748
	2	8.540	17.440
	3	8.600	17.876

Average = 18.02 N/mm2 > 2/3 x target mean strength (2/3 x 27.59) Hence O.K

Table 4 : Results of Compressive Strength

Type of Concrete	Specimen	Weight in Kg	Compressive Strength (28days) N/mm^2
Plain Concrete	1	8.38	28.440
	2	8.340	28.00
	3	8.650	29.55

Average = 28.66 N/mm2 ~ 27.59 N/mm2

Hence O.K

B. Experimental Results of Cube compressive strength

The mortar cubes of size 100mmx100mmx100mm were cast using different Mix proportions and various tests are conducted on cubes for 28 days. Apart from the stress on results the NDT results are also obtained.

a. Ultrasonic Pulse velocity

A pulse of longitudinal vibrations is produced by an electro-acoustical transducer, which is held in contact with one surface of the concrete under test. When the pulse generated is transmitted into the concrete from the transducer using a liquid coupling material such as grease or cellulose paste, it undergoes multiple reflections at the boundaries of the different material phases within the concrete. A complex system of stress waves develops, which include both longitudinal and shear waves, and propagates through the concrete. The first waves to reach the receiving transducer are the longitudinal waves, which are converted into an electrical signal by a second transducer. Electronic timing circuits enable the transit time T of the pulse to be measured. The equipment consists essentially of an electrical pulse generator, a pair of transducers, an amplifier and an electronic timing device for measuring the time interval between the initiation of a pulse generated at the transmitting transducer and its arrival at the receiving transducer. Two forms of electronic timing apparatus and display are available, one of which uses a cathode ray tube on which the received pulse is displayed in relation to a suitable time scale, the other uses an interval timer with a direct reading digital display.

Table 5 : Classification of the quality of concrete on the basis of Pulse velocity

Longitudinal Pulse Velocity m/sec	Quality of concrete
>4500	Excellent
3500-4500	Good
3000-3500	Doubtful
2000-3000	Poor
<2000	Very Poor

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Table 6 : UPV test result of mortar cube specimen

Mix proportion	Time µs	Velocity m/sec	Quality of concrete
Plain Mortar	23.6	4240	Good
Plain Mortar with latex	24.2	3980	Good
Plain Mortar with Latex and Carbon Fibre	23.8	4310	Good
Plain Mortar with Methylcellulose	28.6	3560	Good
Plain Mortar with Methylcellulose and Carbon Fibres	23.3	4290	Good
Plain Mortar with Methylcellulose, Silica Fume	27.5	3640	Good
Plain Mortar with Methylcellulose, Silica Fume and Carbon Fibres	26.6	3760	Good

b. Rebound Hammer

The device consists of a plunger rod, an internal spring loaded steel hammer and a latching mechanism. When the extended plunger rod is pushed against a hard surface, the spring connecting the hammer is stretched and when pushed to an internal limit, the latch is released causing the energy stored in the stretched spring to propel ,the hammer against the plunger tip. The hammer strikes the shoulder of the plunger rod and rebounds a certain distance. On the outside of the unit is a slide indicator that records the distance travelled during the rebound. This indication is known as the rebound number. By pressing the button on the side of the unit, the plunger is then locked in the retracted position and the rebound number (R-number) can be read from the graduated scale. The higher the R-number, the greater is the hardness of the concrete surface.

i) Plain Mortar:

SIDE- I

12	14
18	16

Average: 15N/mm^2

SIDE-II

12	14
18	16

Average: 14 N/mm2

ii) Plain Mortar with Latex

SIDE- I

12	14
18	16

Average: 17.50N/mm^2

SIDE-II

12	14
18	16

Average: 16.50 N/mm2

iii) Plain Mortar with Latex and Carbon Fibers

SIDE- I

12	14

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18	16

Average: 11N/mm2

12	14
18	16

Average: 11.50 N/mm2

iv) Plain Mortar with Methylcellulose

SIDE- I

14	18
16	16

Average: 16N/mm2

12	10
12	16

Average: 12.50 N/mm2

v) Plain Mortar with Methylcellulose and Carbon Fibers

SIDE- I

12	10
12	14

Average: 12 N/mm2

10	14
14	12

Average: 12.50 N/mm2

vi) Plain Mortar with Methylcellulose and Silica Fume

SIDE- I

18	12
12	16

Average: 14.5 N/mm2

10	12
14	12

Average: 12 N/mm2

vii) Plain Mortar with Methylcellulose, Silica Fume and Carbon Fibers

SIDE- I

10	12
10	12

Average: 11 N/mm2

12	10
12	14

Average: 12 N/mm2

Table 7 The average Rebound hammer number for all types

Type of mix proportion	Rebound hammer number
Plain Mortar	14.5
Plain Mortar with Latex	17
Plain Mortar with Latex and carbon fibers	11.25
Plain Mortar with	14.25

Methylcellulose	
Plain Mortar with Methylcellulose and carbon fibers	12.25
Plain Mortar with Methylcellulose, Silica Fume	13.25
Plain Mortar with Methylcellulose, Silica Fume and carbon fibers	11.5

c. Electrical Resistivity of different Mix Proportions

i) Plain Mortar

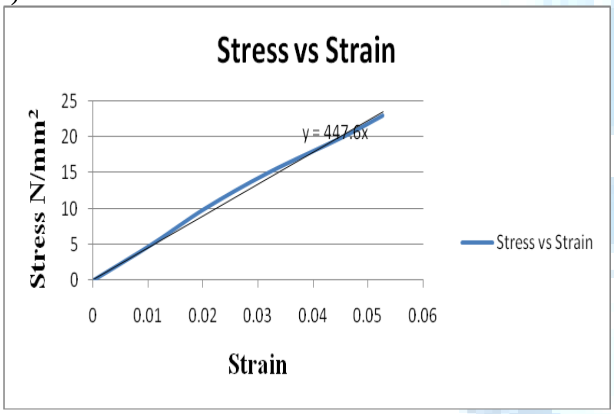

Fig 5 Stress Vs Strain curve in compression for plain Mortar

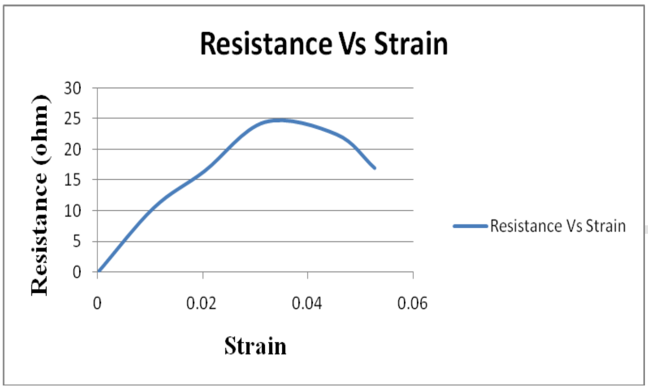

Fig 6 Resistance Vs Strain curve in compression for plain mortar

ii) Plain Mortar with Latex

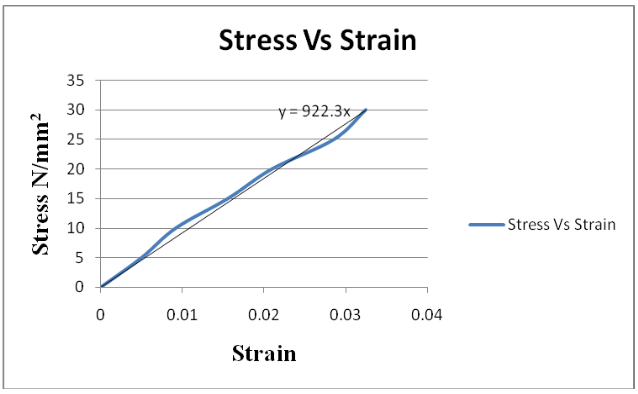

Fig 7 Stress Vs Strain curve in compression for mortar with Latex

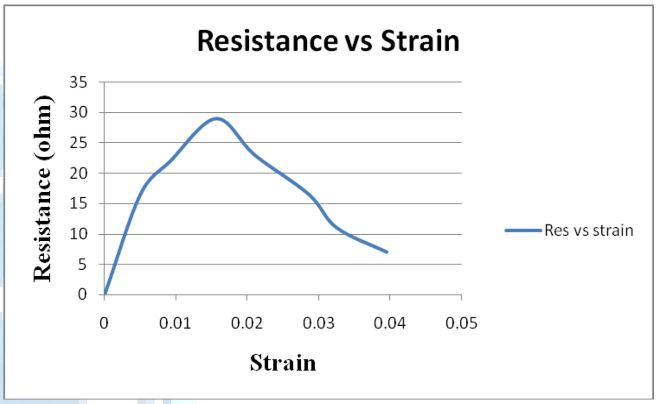

Fig 8 Resistance Vs Strain curve in compression for mortar with Latex

Table 8 Modulus of Elasticity of the specimen

Type of mortar specimen	Modulus of Elasticity N/mm^2
Plain mortar	500
Plain mortar with Latex	1100
Plain mortar with Latex and carbon fibers	1000
Plain mortar with methylcellulose	1000
Plain mortar with methylcellulose and carbon fibers	800
Plain mortar with methylcellulose, silica fume	900
Plain mortar with methylcellulose, silica fume and carbon fibers	500

Table 9 Change in resistance of the specimen per unit strain

Type of mortar specimen	Change in resistance per unit strain (Ohm)
Plain mortar	1000
Plain mortar with Latex	2300
Plain mortar with Latex and carbon fibers	1600
Plain mortar with methylcellulose	700
Plain mortar with methylcellulose and carbon fibers	600
Plain mortar with methylcellulose, silica fume	2000
Plain mortar with methylcellulose, silica fume and carbon fibers	500

VII. Conclusion

A. Strength

The comparison of test specimens and relation to compression strength and is found mix 2 (mortar with latex) is the highest compressive strength.
In comparison with plain mortar this strength is 1.39 times more.
The comparison of test specimen and relation to tensile strength and is found that mix 3(mortar with latex and carbon fibers) is the highest tensile strength.
In comparison with plain mortar this tensile strength is 1.72 times more.

The comparison of test specimen and relation to flexural strength and is found that mix 3(mortar with methylcellulose and silica fume) is the highest strength.
In comparison with plain mortar this flexural strength is 1.1 times more.

B. UPV test

The comparison of test specimens and relation to UPV and is found that all the specimens are in appropriate values when compared to table having classification of the quality of concrete on the basis of pulse velocity which states that the quality of mortar specimens is good

C. Rebound hammer number

The comparison of test specimen and relation to Rebound hammer number and is found that mix 2 (mortar with latex) has the highest Rebound hammer number.
In comparison with plain mortar this rebound hammer number is 1.17 times more.

D. Modulus of Elasticity or Stiffness

The comparison of test specimen and relation to Modulus of Elasticity and is found that mix 2(mortar with latex) is the highest Modulus of Elasticity in compression.
In comparison with plain mortar, modulus of elasticity is 2.2 times more

The comparison of test specimen and relation to Modulus of Elasticity and is found that mix 5(mortar with methylcellulose and carbon fibers) is the highest Modulus of Elasticity in tension.
In comparison with plain mortar, Modulus of Elasticity is 1.38 times more.

The comparison of test specimen and relation to Stiffness and is found that mix 2(mortar with methylcellulose) is the highest Stiffness in flexural.
In comparison with plain mortar, Stiffness is 2.5 times more.

E. Change in resistance

The comparison of test specimen and relation to Change in resistance and is found that mix 2(mortar with latex) is the highest change in resistance in compression.
In comparison with plain mortar, change is resistance is 2.3 times more.

The comparison of test specimen and relation to change in resistance and is found that mix 7(mortar with methylcellulose, silica fume and carbon fibers) is the highest change in resistance in tension.
In comparison with plain mortar, change in resistance is 1.09 times more.

The comparison of test specimen and relation to change in resistance and is found that mix 2(mortar with methylcellulose) is the highest change in resistance in flexural.
In comparison with plain mortar, change in resistance is 4.60 times more.
From the experimental studies it is observed that mortar with latex have highest change in resistance, strength and modulus of elasticity in compression such that this mix is preferred as a smart material.

REFERENCES

[1] Sun Mingqing (1999) “Thermal self-monitoring of carbon fibre reinforced concrete”,Cement and Concrete Research vol.no. 29 (1999) PP. 769–771.

[2] Dragos-Marian Bontea (2000) “Damage in carbon fibre-reinforced concrete, monitored by electrical resistance measurement”, Cement and Concrete Research vol.no. 30 (2000), PP 651-659.

[3] Mingqing Sun (2000) “Piezoelectric properties of carbon fibre reinforced concrete and plain cement paste during dynamic loading”, Cement and Concrete Research vol.no.30 (2000) PP.1593-1595.

[4] Zeng-Qiang Shi and D.D.L.Chung (1999) "Carbon fibre-reinforced concrete for traffic monitoring and weighing in motion", Cement and Concrete Research vol.no. 29 (1999) PP.435–439.
[5] Umit Serdar Camli and Baris Binici (2007) "Strength of carbon fibre reinforced polymers bonded to concrete and masonry", Construction and Building Materials vol.no. 21 (2007) PP.1431–1446